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# LPSN—list of prokaryotic names with standing in nomenclature

**Aidan C. Parte***

LPSN, 261 Willis Road, Sudbury, MA 01776, USA

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## ABSTRACT

**The List of Prokaryotic Names with Standing in Nomenclature (LPSN; http://www.bacterio.net) is a database that lists the names of prokaryotes (*Bacteria* and *Archaea*) that have been validly published in the *International Journal of Systematic and Evolutionary Microbiology* directly or by inclusion in a Validation List, under the Rules of International Code of Nomenclature of Bacteria. Currently there are 15 974 taxa listed. In addition, LPSN has an up-to-date classification of prokaryotes and information on prokaryotic nomenclature and culture collections.**

## INTRODUCTION

The List of Prokaryotic Names with Standing in Nomenclature (LPSN), available at http://www.bacterio.net, was established in 1997 as the of List of Bacterial Names with Standing in Nomenclature (LBSN), which was available for downloading via an FTP server (1). It subsequently was published online on 28 January 1998 and has been updated with the publication of each issue of the *International Journal of Systematic and Bacteriology* (IJSB), renamed *International Journal of Systematic and Evolutionary Microbiology* (IJSEM) in 2000. LPSN was founded and curated by Prof. Jean Euzéby, Ecole Nationale Vétérinaire de Toulouse, Toulouse, France, until his retirement in June 2013 (2). Having collaborated with Prof. Euzéby and been a heavy user of LPSN over the years in my roles as Managing Editor of IJSB, IJSEM and *Bergey's Manual of Systematic Bacteriology*, he entrusted LPSN to me on his retirement. Prof. Euzéby's interest and expertise in systematic bacteriology and Latin and Greek, and his fastidious updates to LPSN have made it the most authoritative source for prokaryotic nomenclature. His work has also been facilitated by his close collaboration with IJSEM's editorial board and staff.

Each year the number of new validly published names increases. In 2000, 370 new names were validly published. This increased to 804 in 2007. As of August, 842 new names were published in 2013 (Table 1). This rapid increase in validly published names illustrates the problem in keeping up with changes in prokaryotic nomenclature. By providing accurate information about the current status of a name, synonyms and other useful information, LPSN is a solution to this problem.

## WHAT IS A VALIDLY PUBLISHED NAME?

Although there is no official classification of prokaryotes, their names are governed by the International Code of Nomenclature of Bacteria (aka the *Bacteriological Code*), an official publication of the International Committee on Systematics of Prokaryotes (ICSP), formerly the International Committee on Systematic Bacteriology (ICSB). The *Bacteriological Code* contains General Considerations, Principles, Rules and Recommendations on the naming of prokaryotes. The *Bacteriological Code* governs names of prokaryotes in the ranks of Class, Subclass, Order, Suborder, Family, Subfamily, Tribe, Subtribe, Genus, Subgenus, Species and Subspecies. Taxa above the rank of Class (Phylum, Kingdom, Division and Domain) are not covered by the Code.

In 1975, the *Bacteriological Code* (1975 Revision) introduced the concept of 'valid publication' of names of prokaryotes. The rationale for this action was largely to reduce the number of redundant, ambiguous and confusing names in common use. The publication of the *Approved Lists of Bacterial Names* (3) was part of this concept, and set a new starting point in prokaryotic nomenclature. The *Approved Lists of Bacterial Names* contain 2212 names of genera, species or subspecies, and 124 names of higher taxa (family and above). 'The names are only approved in the sense that they were approved for retention in the new bacteriological nomenclature' (4).

The *International Code of Nomenclature of Bacteria* (1990 Revision) is the cornerstone of prokaryotic nomenclature (5). It states that the name of a taxon is validly published, and therefore has standing in nomenclature, if one of the following criteria is met: (i) The name is cited in the *Approved Lists of Bacterial Names*. (ii) The name is published in papers in the IJSB or in the IJSEM and conforms to requirements laid down in the

*To whom correspondence should be addressed. Tel: +1 978 443 2820; Email: aidan.parte@gmail.com

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**Table 1.** Names validly published since the Approved Lists of Bacterial Names up to 1 August 2013

| Year | Taxonomic rank | | | | | | | | Annual total |
|---|---|---|---|---|---|---|---|---|---|
| | Class | Subclass | Order | Suborder | Family | Genus | Species | Subspecies | |
| 1980 | 0 | 0 | 0 | 0 | 2 | 10 | 49 | 1 | 62 |
| 1981 | 0 | 0 | 3 | 0 | 5 | 22 | 103 | 7 | 140 |
| 1982 | 0 | 0 | 1 | 0 | 3 | 16 | 102 | 13 | 135 |
| 1983 | 0 | 0 | 0 | 0 | 2 | 27 | 166 | 17 | 212 |
| 1984 | 0 | 0 | 1 | 0 | 4 | 31 | 161 | 23 | 220 |
| 1985 | 0 | 0 | 0 | 0 | 0 | 29 | 125 | 14 | 168 |
| 1986 | 0 | 0 | 1 | 0 | 3 | 27 | 176 | 16 | 223 |
| 1987 | 0 | 0 | 2 | 0 | 2 | 19 | 100 | 11 | 134 |
| 1988 | 5 | 0 | 1 | 0 | 1 | 30 | 144 | 8 | 189 |
| 1989 | 0 | 0 | 2 | 0 | 5 | 23 | 167 | 19 | 216 |
| 1990 | 0 | 0 | 0 | 0 | 3 | 21 | 148 | 30 | 202 |
| 1991 | 0 | 0 | 0 | 0 | 5 | 21 | 145 | 12 | 183 |
| 1992 | 0 | 0 | 0 | 0 | 1 | 0 | 122 | 16 | 139 |
| 1993 | 0 | 0 | 1 | 0 | 2 | 36 | 178 | 6 | 223 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 42 | 161 | 6 | 209 |
| 1995 | 0 | 0 | 1 | 0 | 2 | 37 | 217 | 11 | 268 |
| 1996 | 0 | 0 | 1 | 0 | 3 | 46 | 232 | 20 | 302 |
| 1997 | 1 | 5 | 6 | 10 | 19 | 42 | 223 | 4 | 310 |
| 1998 | 1 | 0 | 0 | 0 | 1 | 55 | 256 | 6 | 319 |
| 1999 | 0 | 0 | 0 | 0 | 4 | 79 | 273 | 14 | 370 |
| 2000 | 0 | 0 | 0 | 0 | 8 | 76 | 275 | 11 | 370 |
| 2001 | 0 | 0 | 0 | 0 | 1 | 68 | 356 | 8 | 433 |
| 2002 | 42 | 0 | 25 | 0 | 14 | 72 | 350 | 9 | 512 |
| 2003 | 1 | 0 | 1 | 0 | 3 | 75 | 372 | 20 | 472 |
| 2004 | 0 | 0 | 3 | 0 | 13 | 80 | 435 | 13 | 544 |
| 2005 | 1 | 0 | 12 | 0 | 20 | 105 | 528 | 6 | 672 |
| 2006 | 6 | 0 | 19 | 1 | 38 | 118 | 593 | 4 | 779 |
| 2007 | 3 | 0 | 5 | 3 | 8 | 135 | 631 | 19 | 804 |
| 2008 | 1 | 0 | 5 | 0 | 11 | 116 | 597 | 8 | 738 |
| 2009 | 2 | 0 | 7 | 2 | 12 | 112 | 663 | 15 | 813 |
| 2010 | 7 | 1 | 9 | 0 | 25 | 105 | 611 | 13 | 771 |
| 2011 | 2 | 0 | 3 | 1 | 11 | 105 | 619 | 13 | 754 |
| 2012 | 9 | 0 | 8 | 0 | 26 | 100 | 655 | 11 | 809 |
| 2013[a] | 16 | 0 | 9 | 4 | 14 | 121 | 666 | 12 | 842 |
| Total | 97 | 6 | 126 | 21 | 271 | 2001 | 10 599 | 416 | 13 537 |

[a]Up to the August issue of IJSEM.

*Bacteriological Code*. (iii) The name is validly published by announcement in a Validation List. Validation Lists are lists published in the IJSB/IJSEM validating prokaryotic names effectively, but not validly published.

Announcement in a Validation List is the responsibility of the author of the name or new combination—authors wishing to submit new names and/or combinations for inclusion in a list must send appropriate documentation to the IJSEM Editorial Office or to the Lists Editor. Following the Paris meeting of the ICSP in August 2002, it is also a requirement that authors of new species, new subspecies and new combinations provide documentary evidence that type strains are deposited in at least two recognized culture collections in two different countries (i.e. documents certifying deposition and availability of type strains) and are available from those culture collections without restrictions.

According to the above criteria, LPSN lists all validly published names of prokaryotes, from the Approved Lists and culled from IJSB/IJSEM and its Validation Lists. It also includes listings of some non-valid names, *Candidatus* taxa (taxa which have been incompletely described and do not meet the requirements for valid publication), endangered prokaryotic names (type strains having only been deposited in a single culture collection) and taxa above the rank of class. Every taxon of rank genus or higher has its own page—~2950 at present, and there are ~150 additional pages of classifications, indices, etc.

## STRUCTURE OF A TYPICAL TAXON ENTRY IN LPSN

Figure 1 is a screenshot of a typical entry for a species in LPSN, in this case *Fictibacillus arsenicus* comb. nov. The first line gives the species name in purple; as this is a new combination, formed by the reclassification of *Bacillus arsenicus*, the authority or reference for the original name or basonym (Shivaji *et al.* 2005) is given in parentheses followed by the authority for the present classification, Glaeser *et al.* 2013. This is followed by the taxon status, in this case comb. nov. (for *combinatio nova*).

The next line gives the type strain and collection strain numbers assigned to the type strain, preceded in parentheses by the hyperlink to StrainInfo.net, which is an integrated microbial knowledge base developed at

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***Fictibacillus arsenicus*** (Shivaji *et al.* 2005) Glaeser *et al.* 2013, comb. nov.
**Type strain:** (see also StrainInfo.net) Con a/3=MTCC 4380=DSM 15822=JCM 12167.
**Sequence accession no. (16S rRNA) for the type strain:** AJ606700.
**Basonym:** ¤ *Bacillus arsenicus* Shivaji *et al.* 2005
**Etymology:** N.L. masc. adj. *arsenicus*, pertaining to arsenic.
**Source:** Animal.
**Reference:** GLAESER, S. P., DOTT, W., BUSSE, H.-J. and KÄMPFER, P. 2013. *Fictibacillus phosphorivorans* gen. nov., sp. nov. and proposal to reclassify *Bacillus arsenicus*, *Bacillus barbaricus*, *Bacillus macauensis*, *Bacillus nanhaiensis*, *Bacillus rigui*, *Bacillus solisalsi* and *Bacillus gelatini* in the genus *Fictibacillus*. *Int. J. Syst. Evol. Microbiol.*, **63**, 2934-2944.
Original article in IJSEM Online

**Figure 1.** Screenshot of a typical entry for a species in LPSN.

Ghent University (6). The GenBank sequence accession number for the 16S rRNA gene of the type strain is provided and hyperlinked. The basonym of the species is given, and a link to its entry in LPSN is provided via the ¤ symbol. The etymology or derivation of the name is listed, where known. The source of isolation of the type strain is given for all new species or subspecies published or validated from the July 2013 issue onwards of IJSEM, followed by the reference to the published article in IJSEM with a hyperlink via the article's DOI. [For taxa that appear on a Validation List, references to the List and the effective publication, again with hyperlinks via the List and article DOIs, are provided when possible.]

## CLASSIFICATION

There is no official classification of prokaryotes, as this is a matter of scientific judgment and general agreement (4). The most widely accepted classification is the 'Taxonomic Outline of the Prokaryotes' initiated in the early 1990s in the editorial office of Bergey's Manual Trust as a preliminary step in organizing the content of the second edition of *Bergey's Manual of Systematic Bacteriology*.

The classification used in the LPSN is based on the original publications, and/or the latest 'Taxonomic Outline of the Bacteria and Archaea' (http://www.taxonomicoutline.org) (7), and/or the 'NCBI Taxonomy Browser' (http://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Root), and/or Taxonomic Outlines for Volumes 3 and 4 of *Bergey's Manual of Systematic Bacteriology* (Second Edition) (8) (9) and/or 'The All-Species Living Tree Project' (10). This classification is subject to revision following examination of large-scale phylogenetic models.

Since taxa above the rank of class are not covered by the Rules of the Bacteriological Code such names cannot be validly published and they are cited in quotes, for example the phylum '*Euryarchaeota*' in Figure 2. Each taxon entry in the classifications links to the individual taxon page.

## SITE STATISTICS

The use of LPSN rose steadily from its inception to a peak in 2007 of 1.8 million visits (Table 2). As of 2012, it was getting ~1.2 million visits a year. Currently there are no statistics monitoring on the site.

**Phylum "Euryarchaeota"**
**Class Archaeoglobi**
**Order Archaeoglobales**
**Family Archaeoglobaceae**
Archaeoglobus - Ferroglobus - Geoglobus

**Figure 2.** Screenshot of part of the classification of the domain *Archaea*.

**Table 2.** Web server statistics for 2003–12[a]

| Year | Visits[b] | Pages[c] |
|---|---|---|
| 2003 | 700 500 | 2 496 106 |
| 2004 | 859 902 | 3 484 600 |
| 2005 | 1 252 369 | 5 945 088 |
| 2006 | 1 780 511 | 7 231 487 |
| 2007 | 1 810 513 | 5 544 509 |
| 2008 | 1 419 144 | 6 532 190 |
| 2009 | 1 406 178 | 5 581 139 |
| 2010 | 1 566 970 | 6 193 619 |
| 2011 | 1 239 165 | 4 434 026 |
| 2012 | 1 249 629 | 4 080 135 |

[a]Statstics generated by Webalizer. In addition to LPSN, Prof. Euzéby was also the author of a website entitled 'Dictionnaire de Bactériologie Vétérinaire'. To avoid additional web hosting fees, 'Dictionnaire de Bactériologie Vétérinaire' was included as a folder in LPSN. So, the statistics given in Table 2 encompass the results of both sites.
[b]Visits occur when some remote site makes a request for a page on the server for the first time. As long as the same site keeps making requests within a given timeout period, they will all be considered part of the same Visit. If the site makes a request to the server, and the length of time since the last request is greater than the specified timeout period (30 min), a new Visit is started and counted, and the sequence repeats. Since only pages will trigger a visit, remotes sites that link to graphic and other non-page URLs will not be counted in the visit totals, reducing the number of false visits.
*Additional information*: Whenever a request is made to the server from a given IP address (site), the amount of time since a previous request by the address is calculated (if any). If the time difference is greater than a pre-configured 'visit timeout' value (or has never made a request before), it is considered a 'new visit', and this total is incremented (both for the site, and the IP address). The timeout value is 30 min, so if a user visits the site at 1:00 in the afternoon, and then returns at 3:00, two visits would be registered.
[c]Pages are those URLs that would be considered the actual page being requested, and not all of the individual items that make it up (such as graphics).

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## SEARCH ENGINE

A Google Custom Search Engine was added to the fixed navigation bar for easy access from any position on every page of the site. Indexing requests are submitted to Google via a sitemap.xml file following the addition of new taxa files.

## NEW DEVELOPMENTS AND PLANS

After Prof. Euzéby's final updates to the site following publication of the June issue of IJSEM, the LPSN was recoded and reformatted using CSS to enable streamlining of the HTML code and to facilitate updates. On 30 June 2013, the site was re-launched on a new server at gandi.net under the URL http://www.bacterio.net. The names published or validated in the July and August issues of IJSEM have been added using a FileMaker Pro database to calculate the HTML. The data for the FileMaker database are imported after manipulating in Word and Excel citations downloaded from PubMed into Endnote and files supplied by the SGM, the publisher of IJSEM. Calculated HTML is then added to existing files or new files are created as necessary, for example when a new genus is added.

In order to make the site more useful, the source of type strains has been added for each new species or subspecies, where available. Current categories are Environmental; Environmental—soil; Environmental—freshwater; Environmental—marine; Human; Clinical; Animal; Veterinary; Oral; Plant; Plant pathogen; Industrial; and Food.

In addition to the StrainInfo.net link, I plan to add links from the type strain designations directly to the major culture collections (such as DSMZ, ATCC, LMG, JCM and KCTC) in order to facilitate ordering strains from the collections. LPSN will be developed to work properly on smartphones and tablets in the near future. The Webalizer web server log file analysis program will be reinstated on LPSN in due course.

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## FUNDING

Currently LPSN is self-funded (as it was by my predecessor), but will accept (and solicit) appropriate sponsors and grants in the future. Advertising has been added on the search results page via the Google AdSense system; thus far, negligible revenue has been generated. The SGM has supplied a complimentary online subscription to IJSEM Online, which has been an invaluable resource. Funding for open access charge: Waived by Oxford University Press.

*Conflict of interest statement*. None declared.

## REFERENCES

1. Euzéby,J.P. (1997) List of bacterial names with standing in nomenclature: a folder available on the internet. *Int. J. Syst. Bacteriol.*, **47**, 590–592.
2. Oren,A. and Garrity,G. (2013) Retirement of Professor Jean Paul Euzéby as list editor. *Int. J. Syst. Evol. Microbiol.*, **63**, 2373.
3. Skerman,V.B.D., McGowan,V. and Sneath,P.H.A. (1980) Approved lists of bacterial names. *Int. J. Syst. Bacteriol.*, **30**, 225–420.
4. Sneath,P.H.A. and Brenner,D.J. (1992) "Official" nomenclature lists. *ASM News*, **58**, 175.
5. Lapage,S.P., Sneath,P.H.A., Lessel,E.F., Skerman,V.B.D., Seeliger,H.P.R. and Clark,W.A. (1992) *International Code of Nomenclature of Bacteria (1990 Revision). Bacteriological Code*. Published for IUMS by the American Society for Microbiology, Washington, DC.
6. Dawyndt,P., Vancanneyt,M., De Meyer,H. and Swings,J. (2005) Knowledge accumulation and resolution of data inconsistencies during the integration of microbial information sources. *IEEE Trans. Knowl. Data Eng.*, **17**, 1111–1126.
7. Garrity,G.M., Lilburn,T.G., Cole,J.R., Harrison,S.H., Euzéby,J. and Tindall,B.J. (2007) Taxonomic Outline of the Bacteria and Archaea, Release 7.7. Michigan State University Board of Trustees. http://dx.doi.org/ (29 October 2013, date last accessed).
8. Ludwig,W., Schleifer,K.-H. and Whitman,W.B. (2009) Taxonomic outline of the phylum *Firmicutes*. In: De Vos,P., Garrity,G.M., Jones,D., Krieg,N.R., Ludwig,W., Rainey,F.A., Schleifer,K.-H. and Whitman,W.B. (eds), *Bergey's Manual of Systematic Bacteriology*, Vol. 3, The *Firmicutes*, 2nd edn. Springer, New York, pp. 15–17.
9. Ludwig,W., Euzéby,J. and Whitman,W.B. (2009) Taxonomic outline of the *phyla Bacteroidetes, Spirochaetes, Tenericutes (Mollicutes), Acidobacteria, Fibrobacteres, Fusobacteria, Dictyoglomi, Gemmatimonadetes, Lentisphaerae, Verrucomicrobia, Chlamydiae*, and *Planctomycetes*. In: Krieg,N.R., Staley,J.T., Hedlund,B., Paster,B.J., Ward,N., Ludwig,W. and Whitman,W.B. (eds), *Bergey's Manual of Systematic Bacteriology*, 2nd edn. Vol. 4, The *Bacteroidetes*, *Spirochaetes*, *Tenericutes* (*Mollicutes*), *Acidobacteria*, *Fibrobacteres*, *Fusobacteria*, *Dictyoglomi*, *Gemmatimonadetes*, *Lentisphaerae*, *Verrucomicrobia*, *Chlamydiae*, and *Planctomycetes*. Springer, New York, pp. 21–24.
10. Yarza,P., Richter,M., Peplies,J., Euzéby,J., Amann,R., Schleifer,K.H., Ludwig,W., Glöckner,F.O. and Rosselló-Móra,R. (2008) The All-Species Living Tree project: a 16S rRNA-based phylogenetic tree of all sequenced type strains. *Syst. Appl. Microbiol.*, **31**, 241–250.

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